

**NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD**

SUBSURFACE DRAIN

(Feet)

CODE 606

DEFINITION

A conduit, such as corrugated plastic tubing, tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water.

PURPOSE

- Improve the soil environment for vegetative growth, reduce erosion, and improve water quality by:
 - ◊ Regulating water table and ground water flows,
 - ◊ Intercepting and preventing water movement into a wet area,
 - ◊ Relieving artesian pressures,
 - ◊ Removing surface runoff,
 - ◊ Leaching of saline and sodic soils,
 - ◊ Serving as an outlet for other subsurface drains, and
 - ◊ Regulating sub-irrigated areas or waste disposal areas.
- Collect ground water for beneficial uses.
- Remove water from heavy use areas, such as around buildings, roads, and play areas; and accomplish other physical improvements related to water removal.
- Regulate water to control health hazards caused by pests such as flukes, flies, or mosquitoes.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to areas having a high water table where the benefits of lowering the

water table or controlling ground water or surface runoff justify installing such a system.

This standard applies to areas suitable for the intended use after installation of required drainage and other conservation practices. The soil shall have enough depth and permeability to permit installation of an effective and economically feasible system.

In areas where an outlet is available, either by gravity flow or by pumping, the outlet shall be adequate for the quantity and quality of effluent to be discharged. Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions under state laws.

Planning and implementation for this practice shall comply with General Manual policy Title 190 Part 410.26, protection of wetlands and all wetland conservation provisions of the Farm Bill.

FEDERAL, STATE AND LOCAL LAWS

All federal, state, and local laws, rules, ordinances and regulations governing wetlands, water quality and safety shall be strictly adhered to. In addition, USDA farm programs may further restrict participants in altering or draining wetlands. The Owner or Operator shall be responsible for securing all required permits and for complying with such laws and regulations. The only exceptions are noted below.

The Project Designer is responsible for contacting the Pennsylvania One Call system for utility notification. All positive responses should be noted on the drawings. It is the Contractor's or Landowner's responsibility to contact the affected utilities at the time of construction.

Accidents from the collapse of trenches are a serious problem in the construction industry.

The Occupational Health and Safety Administration (OSHA) are responsible for policing the construction industry. OSHA publishes a manual (Part 1926, subpart P) on construction safety.

PLANNING CONSIDERATIONS

Subsurface drainage is often installed to make agricultural land more suitable for the installation of other conservation practices. Examples of this are subsurface drainage installed with strip cropping to improve the ease of farming along the contour; installation of subsurface drainage with grassed waterways to improve establishment and maintenance of the grassed waterway; installation of subsurface drainage to collect ground water for ponds and livestock watering facilities; and installation of subsurface drains to relieve hydrostatic pressure around agricultural waste storage structures and ponds.

Subsurface drainage can have a beneficial effect on water quality by improving row crop and small grain plant growth and thereby reducing sheet and rill erosion and the subsequent delivery of sediment and related pollutants to surface water. Care should be taken, however, to insure that pollutants do not enter the drain directly to the emptied into surface waters. Consequently, surface inlets should not be located where they will collect pesticide or herbicide laden water. When subsurface drains are installed around agricultural waste facilities, particular attention should be given to sealing the drain away from the waste. For structures, this involves using watertight joints in the construction. For agricultural waste ponds, sufficient watertight soil should be placed between the drain and the waste to stop migration or the waste to the drain.

CRITERIA

The design and installation shall be based on adequate surveys of the topography and investigations of the soil and subsurface conditions.

Capacity One or more of the following shall determine the required capacity:

- Application of a locally tried and proven drainage coefficient to the acreage drained,

including added capacity required to dispose of surface water entering through inlets.

- Yield of ground water based on the expected deep percolation of irrigation water from the overlying fields, including the leaching requirement.
- Comparison of the site with other similar sites where subsurface drain yields have been measured.
- Measurement of the rate of subsurface flow at the site during a period of adverse weather and ground water conditions.
- Application of Darcy's law to lateral or artesian subsurface flow.
- Estimates of lateral or artesian subsurface flow.
- The use of inflow rates from Table 1 for interceptor drains:

Table 1 - Interceptor drains

Soil Texture	Unified Soil Classification	Inflow Rate per 1,000 ft. of Line in cfs (1)
Coarse Sand & Gravel	GP, GW, SP, SW	0.15 to 1.00
Sandy Loam	SM, SC, GM, GC	0.07 to 0.25
Silt Loam, Loam	CL, ML	0.04 to 0.1
Clay and Clay Loam	CL, CH, MH	0.02 to 0.2

(1) Required inflow rates for interceptor lines on sloping land should be increased by 10% for slopes 2-5%, by 20% for slopes 5-12%.

Size The size of subsurface drains shall be computed by applying Manning's formula. The size shall be based on the required capacity and computed by using one of the following assumptions:

1. The hydraulic grade line is parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow.
2. The conduit flowing partly full where a steep grade or other conditions require excess capacity.
3. Conduit flowing under pressure with hydraulic grade line set by site conditions on a

grade that differs from that of the subsurface drain. This procedure shall be used only if surface water inlets or nearness of the conduit to outlets with fixed water elevations permit satisfactory estimates of hydraulic pressure and flows under design conditions.

Simple interceptor or random drains may be designed without calculating "Q" if the total length of the subsurface drain system does not exceed the maximum lengths in [Table 2](#) and surface water or heavy spring flows are not added to the drain.

Table 2 – Maximum Lengths

Minimum Grade or Subsurface Drain Percent	Maximum Length (ft) 4" Diameter	Maximum Length (ft) 6" Diameter
0.1	300	800
0.2	400	1,200
0.3	500	1,500
0.4	600	1,700
0.5	700	1,900
1.0	900	2,700
1.5	1,100	3,300
2.0	1,300	3,800
2.5	1,500	4,200
3.0	1,600	4,600
4.0	1,800	5,400
5.0	2,000	5,800

All subsurface drains shall have a nominal diameter that equals or exceeds 3 inches.

Depth, Spacing, and Location The depth, spacing, and location of the subsurface drain shall be based on site conditions, including soils, topography, ground water conditions, crops, land use, outlets, and saline or sodic conditions.

The minimum depth of cover over subsurface drains in mineral soils shall be 2 feet. This minimum depth shall apply to normal field levels and may exclude sections of line near the outlet sections laid through minor depressions where the conduit is not subject to damage by frost action or equipment travel.

The minimum depth of cover in organic soils shall be 2.5 feet for normal field levels, as defined above, after initial subsidence. Structural measures shall be installed if it is feasible to control the water table level in organic soils within the optimum range of depths.

The maximum depth of cover for standard duty corrugated plastic tubing shall be 10 feet for trench widths of 2 feet or less (measured at tubing and to 1 foot above the top of tubing). Heavy-duty tubing shall be specified for depths greater than 10 feet, trench widths more than 2 feet, or in rocky soils.

For computation of maximum allowable loads on subsurface drains, use the trench and bedding conditions specified and the crushing strength of the kind and class of drain. The design load on the conduit shall be based on a combination of equipment loads and trench loads. Equipment loads are based on the maximum expected wheel loads for the equipment to be used, the minimum height of cover over the conduit, and the trench width. Equipment loads on the conduit may be neglected when the depth of cover exceeds 6 feet. Trench loads are based on the type of backfill over the conduit, the width of the trench, and the unit weight of the backfill material. A safety factor of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

Minimum Velocity and Grade In areas where sedimentation is not a hazard, the minimum grades shall be based on site conditions and a velocity of not less than 0.5 feet per second (ft/s). If a hazard exists, a velocity of not less than 1.4 ft/s shall be used to establish the minimum grades if site conditions permit. Otherwise, provisions shall be made for preventing sedimentation by use of filters or by collecting and periodically removing sediment from installed traps, or by periodically cleaning the lines with high-pressure jetting systems or cleaning solutions.

Maximum Velocity without Protection Design velocities shall not exceed those given in [Table 3](#) unless special protective measures are installed.

Table 3 - Maximum Velocities by Soil Texture

Soil Texture	Velocity, ft/s
Sand and sandy loam	3.5
Silt and silt loam	5.0
Silty clay loam	6.0
Clay and clay loam	7.0
Coarse sand or gravel	9.0

Maximum Grade and Protection On sites where topographic conditions require that drain lines be placed on steep grades and design velocities will be greater than indicated in Table 1, special measures shall be used to protect the conduit or surrounding soil. These measures shall be specified for each job according to the particular conditions of the job site.

The protective measure shall include one or more of the following:

- Enclose continuous perforated pipe or tubing with fabric-type filter material or properly graded sand and gravel.
- Use non-perforated continuous tubing, a watertight pipe, or seal joints.
- Place the conduit in a sand and gravel envelope or blinding with the least erodible soil available.
- Select rigid butt end pipe or tile with straight, smooth sections and square ends to obtain tight fitting joints.
- Wrap open joints of the pipe or tile with tar impregnated paper, burlap, or special fabric-type filter material.
- Install open-air risers for air release or entry.

Iron Ochre Control If drains are to be installed in sites where iron ochre and manganese dioxide problems are likely to occur, provisions should be made to provide access for cleaning the lines. Each drain line should outlet directly into an open ditch and/or should have entry ports as needed to provide access for cleaning equipment. Drain cleaning provisions should be installed in such a way that the drains can be cleaned in an upstream or rising grade direction. If possible, drains in ochre-prone areas should be installed during the dry season when the water table is low and the iron and manganese dioxide is in its insoluble form.

Where possible, in areas where the potential for such problems is high, protection against their development can be provided by designing an outlet facility to ensure permanent submergence of the drain line.

Protection against Root Clogging Problems may occur where it is necessary to place drains

in close proximity to perennial vegetation. Roots of water-loving trees, such as willow, cottonwood, elm, and soft maple, or some shrubs and grasses growing near subsurface drains may enter and obstruct the flow.

Where possible, use non-perforated tubing or closed joints through the root zone area. Where this is not possible, water-loving trees should be removed from a distance of at least 100 feet on each side of the drain. A distance of 50 feet should be maintained from other species of trees except for fruit trees. Orchards can often be drained by drain lines located close to the fruit trees.

Where crops and grasses may cause trouble on drain lines, facilities may be installed to provide a means for submerging the line to terminate the root growth as desired or to maintain a water table above the drain lines to prevent growth into the system.

Materials Subsurface drains include conduits of plastic, clay, concrete, bituminized fiber, metal, or other materials of acceptable quality.

The conduit shall meet strength and durability requirements for the site. All conduits shall meet or exceed the minimum requirements of the appropriate specifications published by the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), and the American Water Works Association (AWWA).

Foundation If soft or yielding foundations are encountered, the lines shall be stabilized and protected from settlement by adding gravel or other suitable materials to the trench, by placing the conduit on a treated plank that will not readily decompose or on other rigid supports, or by using long sections or perforated or watertight pipe having adequate strength to ensure satisfactory subsurface drain performance. The use of a flat treated plank is not recommended for corrugated plastic tubing.

Filters and Filter Material Filters will be used around conduits, as needed, to prevent movement of the surrounding soil material into the conduit. The need for a filter will be determined by the characteristics of the surrounding soil material, site conditions, and

the velocity of flow in the conduit. A suitable filter should be specified if:

- Local experience indicated a need.
- Soil materials surrounding the conduit are dispersed clays, silts with a plasticity index less than 7, or fine sands with a plasticity index less than 7.
- Deep soil cracking is expected, or
- The method of installation may result in voids between the conduit and backfill material.

If a sand-gravel filter is specified, the filter gradation shall be designed in accordance with National Engineering Handbook (NEH) Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters.

Specified filter material must completely encase the conduit so that all openings are covered with at least 3 inches of filter material except that the top of the conduit and side filter material may be covered by a sheet of plastic or similar impervious material to reduce the quantity of filter material required. In all cases the resulting flow pattern through filter material shall be a minimum of 3 inches.

Artificial fabric or mat-type filter materials may be used, provided that the effective opening size, strength, durability, and permeability are adequate to prevent soil movement into the drain throughout the expected life of the system.

Envelopes and Envelope Material Envelopes shall be used around subsurface drains if they are needed for proper bedding of the conduit or to improve the characteristics of flow of ground water into the conduit.

Materials used for envelopes do not need to meet the gradation requirements of filters, but they must not contain materials that will cause an accumulation of sediment in the conduit or that will render the envelope unsuitable for bedding of the conduit.

Envelope materials shall consist of sand-gravel, organic, or similar material. Sand-gravel envelope materials shall all pass a 1 ½ inch sieve; 90%-100% shall pass a ¾ inch sieve; and not more than 10% shall pass a No. 60 sieve. ASTM-C-33 fine aggregate for concrete has been satisfactorily used and is readily available.

Where organic or other compressible materials are used, they shall be used only around a rigid wall conduit and above the centerline of flexible tubing. All organic or other compressible material shall be of a type that will not readily decompose.

Placement and Bedding All subsurface drains, whether they are a flexible conduit such as plastic or bituminized fiber or rigid conduits such as clay or concrete shall be laid to a neat line and grade. Proper placement and bedding of the conduit lessens the likelihood of crushing the conduit during backfilling and from loading by heavy equipment. The conduit shall be placed and bedded as shown and described in ASTM-F-449, "Standard Recommended Practice for Subsurface Installation of Corrugated Thermoplastic Tubing for Agricultural Drainage or Water Table Control."

The conduit should not be placed on exposed rock, or stones larger than 1.5 inches in diameter for 6 inch or larger diameter tile, and stones no larger than ¾ inch diameter for tile less than 6 inches in diameter. Where such conditions are present, the trench must be over-excavated a minimum of 6 inches and refilled to grade with a suitable bedding material.

The conduit must be placed on a firm foundation to ensure proper alignment. Prevent runoff and surface water from entering the trench.

If installation will be below a water table or where unstable soils are present, special equipment, installation procedures, or bedding materials may be needed. These special requirements may also be necessary to prevent soil movement into the drain or plugging of the envelope if installation will be made in such materials as quicksand or silt slurry.

For trench installations of corrugated plastic tubing 8 inches or less in diameter, one of the following bedding methods will be specified:

- A shaped groove or 90° V-notch in the bottom of the trench for tubing support and alignment.
- A sand-gravel envelope, at least 3 inches thick, to provide support.
- Compacted soil bedding material beside and to 3 inches above the tubing.

For trench installations of corrugated plastic tubing larger than 8 inches, the same bedding requirements will be met except that a semi-circular or trapezoidal groove shaped to fit the conduit will be used rather than a V-shaped groove.

For rigid conduits installed in a trench, the same requirements will be met except that a groove or notch is not required.

All trench installations should be made when the soil profile is in its driest possible condition in order to minimize problems of trench stability, conduit alignment, and soil movement into the drain.

For trench installations where a sand-gravel or compacted bedding is not specified, the conduit should be blinded with selected material containing no hard objects larger than 1.5 inches in diameter. Blinding should be carried to a minimum of 3 inches above the conduit.

Drains which will intercept water containing dissolved iron, aluminum or manganese may become clogged with mineral oxide precipitates. This problem will become worse with increased pH and aeration of the water. Consequently, limestone gravel should not be used to bed conduits which will carry this type of water. In addition, limiting the amount of air in the line by installation of "J" traps or submergence of the outlet should be considered where applicable.

All installations shall meet the minimum requirements of the appropriate ASTM specification.

Auxiliary Structures and Protection

Structures installed in drain lines must not unduly impede the flow of water in the system. Their capacity must be no less than that of the line or lines feeding into or through them. The use of internal couplers for corrugated plastic tubing will be allowed.

If the drain system is to carry surface water flow, the capacity of the surface water inlet shall not be greater than the maximum design flow in the drain line or lines. Covers or trash racks should be used to ensure that no foreign materials are allowed in the drain lines.

The quality of water collected and discharged from subsurface drains must be considered

when selecting an outlet. If there is likelihood for the water to contain materials detrimental to water quality or aquatic life, the outlet shall be located as far as practical from a water body. Drains or appurtenance near manure/wastewater storage facilities risk receiving pollution from spills, runoff and leaks. Drains discharging directly to streams or ground water substantially increase the liability of the landowner if there is a release of pollutants. Allow adequate opportunity to monitor and manage flow from these drains before it reaches streams or ground water. Whenever possible, outlets shall discharge into vegetated, stable waterways where flow can be observed and response taken, if needed. When necessary to outlet directly to water bodies, consider sumps to pump polluted discharges into filter areas, constructed wetlands or storages. Known contaminated water shall not be discharged directly to water bodies.

The capacity of a relief well system will be based on the flow from the aquifer, the well spacing, and other site conditions and will be adequate to lower the artesian water head to the desired level.

The size of relief wells is generally based on the available materials rather than on hydraulic considerations. Such wells will not be less than 4 inches in diameter.

Junction boxes, manholes, catch basins, and sand traps must be accessible for maintenance. A clear opening of not less than 2 feet will be provided in either circular or rectangular structures.

The drain system must be protected against velocities exceeding those given in Table 1 and against turbulence created near outlets, surface inlets or similar structures. Continuous or closed-joint pipe must be used in drain lines adjoining the structure where excessive velocities will occur.

Junction boxes shall be installed where three or more lines join or if two lines join at different elevations. In some locations it may be desirable to bury junction boxes. A solid cover should be used, and the junction box should have a minimum of 1.5 feet of soil cover.

If not connected to a structure, the upper end of each subsurface drain line will be capped with a tight-fitting external cap of the same material as the conduit or other durable materials.

The outlet must be protected against erosion and undermining of the conduit, entry of tree roots, damaging periods of submergence, and entry of rodents or other animals into the subsurface drain. A continuous section of rigid pipe without open joints or perforations will be used at the outlet end of the line and must discharge above the normal elevation of low flow in the outlet ditch. Corrugated plastic tubing is not suitable for the outlet section where there is sufficient cover. SDR-35 PVC pipe is the thinnest walled plastic pipe which may be used for an outlet. It is often helpful to mark the location of outlets in inaccessible areas with brightly colored stake for future reference.

Continuously submerged outlets will be permitted for water table control systems if planned and designed according to the standard for Drainage Water Management (code 554).

The outlet pipe and its installation will conform to the following requirements:

- 1) If burning vegetation on the outlet ditch bank is likely to create a fire hazard; the material from which the outlet pipe is fabricated must be fire resistant. If the likelihood is great, the outlet pipe must be fireproof.
- 2) Two-thirds of the pipe will be buried in the ditch bank, and the cantilever section must extend to the toe of the ditch side slope or the side slope protected from erosion. The minimum length of the pipe will normally be 8 feet. Under certain conditions shorter sections are appropriate; e.g., steep-sided main and laterals (1 (horizontal) : 1 (vertical) or less) with a narrow bottom width of 3 feet, commonly referred to as "minimum ditches," for out letting individual subsurface drain laterals. For conduits 10 inches in diameter and greater, longer outlet sections shall be considered, such as:
 - 10 inches and 12 inches in diameter, use 12 feet.
 - 15 inches and 18 inches in diameter, use 16 feet.
 - Use 20 feet outlet pipe for all diameter larger than 18 inches.
- 3) If ice or floating debris may damage the outlet pipe, the outlet shall be recessed to the extent that the cantilevered part of the pipe will be protected from the current in the ditch.
- 4) Headwalls used for subsurface drain outlets must be adequate in strength and design to avoid washouts and other failures.
- 5) Flap gates, rods, screens or similar protection should be used on all outlets to exclude small animals. Grating bars or attached screens should not be used on drain lines that have surface inlets since debris may enter through the inlets and collect on the grating. Flap gates shall be used on these installations.
- 6) If PVC plastic is used and will be exposed to direct sunlight, it shall be painted with a dark color latex paint

Watertight conduits strong enough to withstand the expected loads will be used if subsurface drains cross under irrigation canals, ditches, or other structures. Conduits under roadways must be designed to withstand the expected loads. Shallow subsurface drains through depressed or low areas and near outlets must be protected from damage caused by farm machinery and other equipment and from freezing and thawing.

DESIGN CONSIDERATIONS

When designing subsurface drainage systems, consider the effects the system will have on water quantity and quality.

Effects on quantity to consider include: water budget, base flow and runoff to water uses and users, groundwater recharge, and volume of soil water needed to improve plant growth.

Water quality effects that should be considered include: delivery of sediment, changes in the delivery of dissolved salts, such as nitrates, on downstream water uses and users, changes in delivery of dissolved substances to the aquifer, downstream water temperatures, and the effects on the visual quality of downstream water.

If a concern exists of tile lines picking up polluted water from manure spreading, consider installing tile blocks, stoppable catch basins, or other temporary flow blocking devices.

Consideration should be given to using subsurface drainage to control high water tables in areas where septic tanks and leach fields exist.

Consider adding collector mains to minimize the visual impact, potential fear from ice or debris damage, and to facilitate maintenance of the grassed ditch bank.

The ability to drain and treat saline and sodic soils shall be considered where this is a problem.

Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions under federal, state, or local laws. Consideration shall be given to maintaining or enhancing environmental values.

Considerations must be given to preventing adverse impacts to delineated wetlands regulated by State and Federal regulations.

PLANS AND SPECIFICATIONS

Plans and specifications for installing subsurface drains shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE A site specific operation and maintenance plan shall be developed for and reviewed with the landowner or operator prior to installation of the constructed wetland. The plan shall be consistent with the purposes of the practice, its

intended life, safety requirements and the design.

REFERENCES

1. American Society for Testing Materials, 1997, ASTM-F-405, *Standard Specification for Corrugated Polyethylene Tubing and Fittings*.
2. American Society for Testing Materials, 2002, ASTM-F-449, *Standard Practice for Subsurface Installation of Corrugated Thermoplastic Tubing for Agricultural Drainage or Water Table Control*.
3. American Society for Testing Materials, 1997, ASTM-F-667, *Standard Specification for Large Diameter Corrugate Polyethylene Tubing and Fittings*.
4. United States Department of Agriculture, Natural Resources Conservation Service, 1984, *Engineering Field Handbook*.
5. United States Department of Agriculture, Natural Resources Conservation Service, *National Engineering Handbook, 2001*, Part 650, Engineering Field Handbook, Chapter 14, Water Management (Drainage).
6. United States Department of Agriculture, Natural Resources Conservation Service, 1971, *Pennsylvania Drainage Guide*